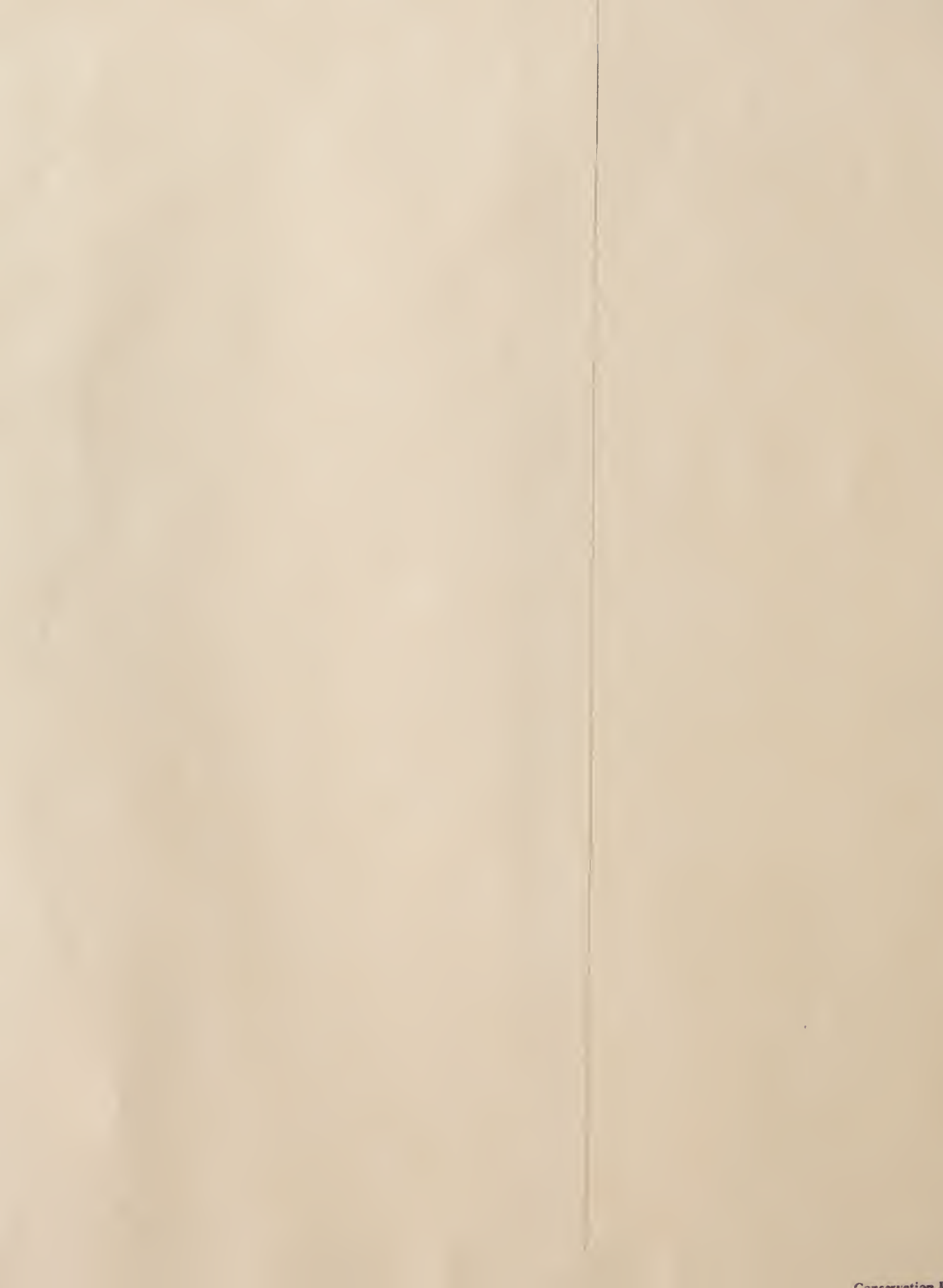


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BETON-COIGNET:

DESCRIPTION OF THE MATERIAL AND ITS USES,

IN

FRANCE AND AMERICA,

WITH

REPORTS OF DISTINGUISHED ENGINEERS AND ARCHITECTS.

PUBLISHED BY

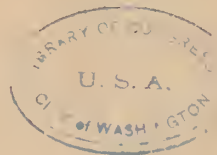
JOHN C. GOODRIDGE, Jr.

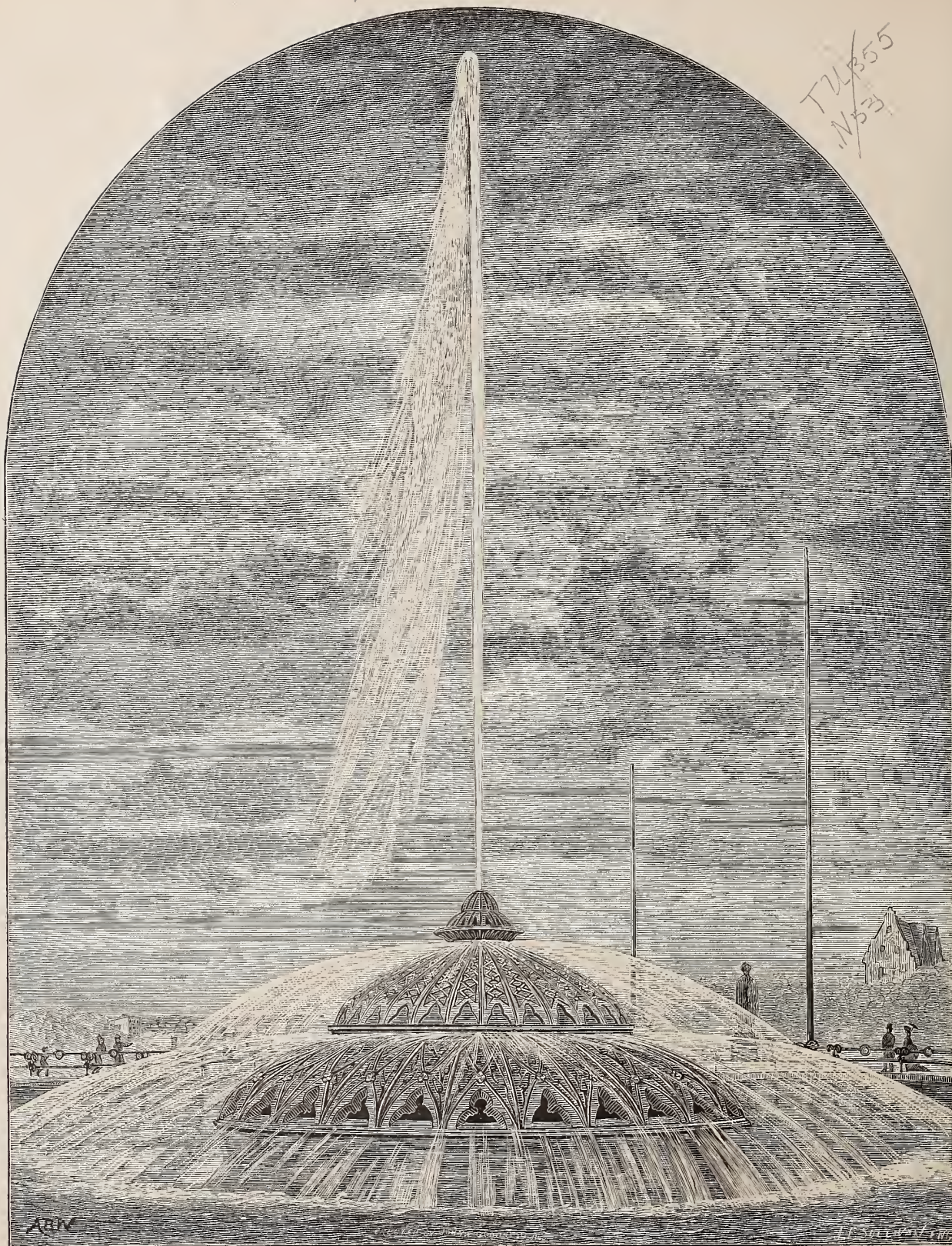
N. Y. & L. I. COIGNET STONE CO.

OFFICE AND FACTORY:

THIRD AVENUE, near THIRD STREET, BROOKLYN, N. Y.

JAMES SUTTON & CO., PRINTERS, 23 LIBERTY STREET, NEW YORK.





Plaza Fountain, Prospect Park, Brooklyn. Built of Beton-Coignet, 1873.

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BETON-COIGNET.

EXTRACT FROM A REPORT ON BETON-COIGNET.

Professional Papers, Corps of Engineers, U. S. A., No. 19.

BY Q. A. GILLMORE,

Major Corps of Engineers, Brevet Major-General U. S. A.

3. This name is given to a béton of very superior quality, or, more properly speaking, an artificial stone of great strength and hardness, which has resulted from the experiments and researches, extending through many years, of M. François Coignet, of Paris.

96. The use of béton aggloméré in France dates back to the year 1856, and confidence in its value has been constantly on the increase since that date.

57. USES OF BETON AGGLOMERE IN EUROPE AND ELSEWHERE.—The most important and costly work that has yet been undertaken in this material, is a section, thirty-seven miles in length, of the Vanne aqueduct, for supplying water to the city of Paris.

This aqueduct, which traverses the forest of Fontainebleau through its entire length, comprises two and a half to three miles of arches, some of them as much as fifty feet in height, and eleven miles of tunnels, nearly all constructed of the material excavated, the impalpable sand of marine formation known under the generic name of Fontainebleau sand. It includes, also, eight or ten bridges of large span (seventy-five to one hundred and twenty-five feet), for the bridging of rivers, canals, and highways.

The smaller arches are half circles, and are generally of a uniform span of $39\frac{37}{100}$, with a thickness at the crown of $15\frac{3}{4}$ inches. Their construction was carried on without interruption through the winter of 1868-9 and the following summer, and the character of the work was not affected by either extreme of temperature. The spandrels are carried up in open work to the level of the crown, and upon the arcade thus prepared the aqueduct pipe is moulded in the same material, the whole becoming firmly knit together into a perfect monolith. The pipe is circular, $6\frac{1}{2}$ feet in interior diameter, with a thickness of 9 inches at the top, and 12 inches at the sides, at the water surface. The construction of the arches is carried on about two weeks in advance of work on the pipe, and the centres are struck about a week later.

Water was let into a portion of this pipe in the spring of 1869, and M. Belgrand, inspector general of bridges and highways, and director of drainage and sewers of the city of Paris, certified that "*the impermeability appeared complete.*"

58. Another interesting application of this material has been made in the construction, completed, or very nearly so, of the light-house at Port Said, Egypt. It will be 180 feet high, without joints, and resting upon a monolithic block of béton, containing nearly 400 cubic yards. In design it is an exact copy of the Baleines light-house, executed after the plans and under the orders of M. Léonce-Regnaud, engineer-in-chief.

59. An entire Gothic church, with its foundations, walls and steeple, in a single piece, has been built of this material at Vésinet, near Paris. The steeple is 130 feet high, and shows no cracks or other evidences of weakness.

M. Pallu, the founder, certifies that "during the two years consumed by M. Coignet in the building of this church, the béton aggloméré, in all its stages, was exposed to rain and frost, and that it has perfectly resisted all variations of temperature."

The entire floor of the church is paved with the same material in a variety of beautiful designs, and with an agreeable contrast of colors.

60. In constructing the municipal barracks of Notre Dame, Paris, the arched ceilings of the cellars were made of this béton, each arch being a single mass. The spans varied from 22 to 25 feet, the rise, in all cases, being one-tenth the span, and the thickness at the crown 8.66 inches. In the same building the arched ceilings of the three stories of galleries, one above the other, facing the interior, and all the subterranean drainage, comprising nearly 600 yards of sewers, are also monoliths of béton.

One of these vault arches, having a span of $17\frac{1}{2}$ feet, was subjected to three severe trial tests, viz:

First. A pyramid of stone-work weighing 36 tons of 2,000 lbs. each, was placed on the centre of the vault.

Second. A mass of sand, 13 feet thick, was spread over the surface of the same vault.

Third. Carts loaded with heavy materials were driven over it.

In no instance was the slightest effect produced.

61. A portion of the basement work of the Paris Exposition building comprised a system of groined arches, supported by columns about $13\frac{3}{4}$ inches square and 10 feet apart. The arches, having a uniform rise of one-tenth the span, and a thickness at the crown of $5\frac{1}{2}$ inches, are monoliths of béton aggloméré. A system of flat cylindrical arches, of 10 feet span, covers the ventilating passages. They have a rise of one-tenth, and a thickness at the crown of not quite 8 inches, and were tested with a distributed weight of 3,300 lbs. to the superficial yard.

There was consumed in the construction of this basement-work more than 353,000 cubic feet of béton.

Béton-coignet becomes in process of time as impervious to water as many of the compact natural stones, while its matured strength exceeds that of the best qualities of sandstone, some of the granites, and many of the limestones and marbles.

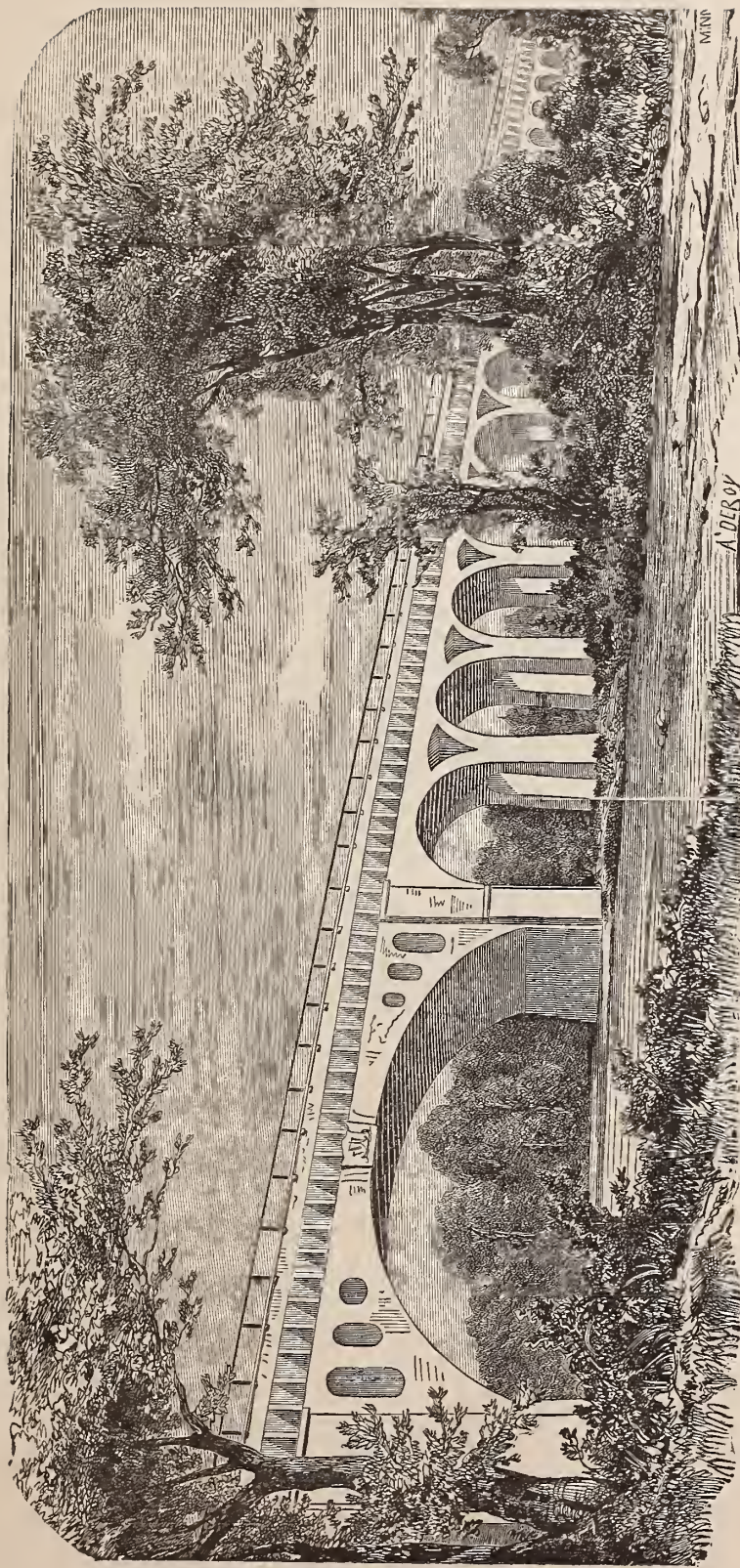
Chemical tests have shown this béton to be practically impervious to water. Two small specimens, each weighing about $2\frac{1}{2}$ grammes, were tried by Dr. Isidor Walz, chemist, of New York City. Their specific gravity was 2.305. They were immersed in water fifteen minutes, and then kept four days in air, saturated with moisture. One of the specimens did not increase in weight at all during the interval, while the other absorbed 16-100 of one per cent. of moisture.

This material, therefore, possesses all the characteristic properties of durability, being dense, hard, strong, and homogeneous; and there would appear to be no reason for supposing that it may not, with entire safety, be applied to out-door constructions, even in the most northerly portions of the United States.

It is injured by freezing before it has had time to set. Important works should not, therefore, be executed during the winter in cold climates.

The effect of freezing on newly made béton is to detach a thin scale from the exposed surface, producing a rough and unsightly appearance; but the injury does not extend into the mass of the material, unless the frost be very intense.

In monolithic constructions, the plank coffre affords sufficient protection to the face surfaces of the work against moderate frost, and, when the temperature ranges generally not much lower than the freezing point during the day, work may be safely carried on, if care be taken to cover over the new material at night. After it has once set, and has had a few hours to harden, neither severe frost, nor alternate freezing and thawing, has any perceptible effect upon it, and, under any and all circumstances, it is much less liable to injury from these causes, and requires fewer precautions for its protection against them, than common hydraulic concrete.



The Vanne Aqueduct. Built of Beton-Coignet, 1868.

Monolithic constructions in béton aggloméré may advantageously be carried on whenever it is not too cold to lay first-class brick masonry.

In Paris and vicinity operations are not generally suspended during the winter, unless the cold be unusually severe for that climate.

Pieces of statuary, and other specimens ornamented with delicate tracery, have been exposed for five consecutive winters to the weather in New York City without undergoing the slightest perceptible change.

62. Over thirty-one miles of the Paris sewers had been laid in this material prior to June, 1869, at a saving of 20 per cent. on their lowest estimated cost in any other kind of masonry.

63. Several large city houses, some for places of residence, and others for business purposes, have been constructed, and many others are in contemplation. In these the entire masonry, comprising both the exterior and the partition walls, the chimneys with flues, cellar arches, cistern, &c., is a single monolith of béton aggloméré.

In one house, having a cellar below the street level, and six full stories, surmounted with a Mansard roof above, the thickness of the exterior wall was established as follows, viz.: cellar, 19.7 inches; first story, 15.7 inches; second story, 13.8 inches; third story, 12.8 inches; fourth story, 11.8 inches; fifth story, 10.8 inches; sixth story, 9.8 inches.

The cellars of such houses are usually divided into two large compartments by a wall parallel to the street, and these are covered by a flat arch of béton, the usual proportions of which are a rise of one-tenth the span, a thickness at the crown of $5\frac{1}{4}$ to $5\frac{1}{2}$ inches, and a thickness at the springing line of $8\frac{1}{4}$ to 9 inches.

Spaces not exceeding thirteen or fourteen feet in width may be spanned by flat platforms from ten to twelve inches thick, and, similarly, the pavements of sidewalks may be in one continuous piece of béton, with street vaults below.

64. An interesting application of this material in the construction of a hollow sustaining wall was made at the cemetery of Passy, in supporting a bank of earth $29\frac{1}{2}$ feet in height. In that wall the volume of the hollows is equal to 53 per cent. of the aggregate volume of béton. The hollows were filled with dry earth.

65. The jetties at the entrance of the Suez Canal are built of béton-coignet. The construction is not monolithic, the béton having been formed into blocks, weighing about twenty tons each on land, where they were allowed to harden for two or three months before they were used. The jetties are twenty-six yards wide at the base and six yards wide at the summit, and are twelve yards in height. About sixteen thousand blocks have thus far been used in their construction, and but little remains to be done toward their completion.

66. All the works above referred to, except those at Port Said, were visited by the writer in the month of February, 1870, and these statements are based upon close observation and personal knowledge.

Many other interesting applications of this material were examined, of which it is not deemed necessary to make any special mention, except that in combined stability, strength, beauty, and cheapness, they far surpass the best results that could have been achieved by the use of any other materials, whether stone, brick, or wood.

Carefully laid on a roof surface over arches, it is claimed that the usual bituminous covering may be dispensed with.

In the numerous and varied applications which have been made of it in France, it has received the most emphatic commendations from the government engineers and architects.

Monolithic buildings in béton, with arched ceilings in all the rooms, are practically fire-proof.

68. Foundations, generally, both in and out of water; for the piers, arches, and roof surfaces of casements; for parade and breast-height walls, &c., &c.

67. For warehouses, churches, and large buildings of every description; for foundations, quay-walls, light-houses, jetties and piers; for abutments and massive walls of all kinds; for





The Vanne Aqueduct. Built in 1868.

sidewalks, platforms, and flagging, and for many other minor purposes, béton aggloméré possesses not only great comparative cheapness, but all the essential merits of brick and stone with respect to strength, hardness, and durability; while for many purposes, such as cellars and cellar floors, cisterns, reservoirs, tanks, and fountains, arches, vaulted ceilings, and vaults, tunnels, aqueducts, sewer and water pipes, and ornamental work of every description within the province of the architect or engineer, it possesses advantages peculiar to itself, and not equally shared by other materials.

Extracts from a Report made by Francois Coignet, to the Civil Engineer of Paris, March 19th, 1869:

"GENTLEMEN—You have already on several occasions received with favor the communications which I have made to you in reference to the uses and applications of the agglomerate invented by me.

"I shall dwell no longer upon this point (the mode of preparation), which to-day is perfectly demonstrated. I shall not refer to the works already accomplished, and to which I have called your attention in my preceding communications, such as the saw-mill of Mr. Hinguerlot; the church of Vésinet; the sustaining wall of the Boulevard de l'Empereur; the works of the Exposition, and the twenty-five to thirty miles of sewers in the city of Paris. I only desire to call your attention to the new uses to which it has been applied within two years.

"In the first place, I will mention the eight or ten large buildings which we have constructed in Paris. They are five and six stories high, are built exclusively of agglomerate from top to bottom, and it has proved practical to reduce the thickness of the walls to a remarkable extent. The *façades* of these buildings are ornamented, and though several of them were built in mid-winter, their resistance to frost is absolute, even in those the roofs of which are terraced in this material. Its use, then, for the construction of houses, is an accomplished fact, and in the perfection attained our hopes have been more than realized.

"I would further bring to your notice its application to a purpose which, though more limited, is not without its importance—that is, to the construction of foundations, vaults, and the underground portions of buildings of any size. In regard to this there can be no two opinions, and the most eminent engineers and architects who have examined the foundations that we have constructed are unanimous in their praise. For this class of work the material is perfection itself—strength under every trial, the absence of joints and consequent freedom from all infiltration, beauty of form, smoothness of surface, although without plastering, reduction of bulk, economy in expense, and unexampled boldness of arches—all these qualities are here found combined.

"I can cite, as the most perfect type of this special application, the foundations of our house in the Rue Miroménil, and particularly those of the out-houses of the mansion of Mr. E. André, on the Boulevard Haussmann, the vaults of which are so extensive, with such a reduced thickness of wall, and with such flat arches of so great a span, that it is safe to say it would be impossible to construct similar work out of the materials usually employed, and in this opinion we are sustained by the most competent architects. I would likewise call your attention to the sustaining wall of the cemetery of Passy, which is truly monumental, as well as to the great collecting sewer which leads from Paris to La Briche, and which has cost a million and a half of francs. This sewer has been built under difficulties of every kind—among them, especially, a succession of inundations; for, through a great part of its length, it ran alongside an old sewer in bad repair, which constantly discharged its waters into the deepest cuttings.

"This sewer included a tunnel, which it was necessary for us to construct in order to pass under the track of the Railway du Nord, and we succeeded perfectly, in spite of the jarring of the trains, and of five successive inundations of the river Seine.

" This sewer, finished a year and a half ago, is a monolithic tube, without joints ; its hardness and its homogeneity are all that could be desired, and notwithstanding all the great difficulties above mentioned, it is without a single crack, and shows no evidence of weakness.

" But of all the works which we have undertaken, the most important is, beyond dispute, the construction of the Aqueduct of Vanne, from the River Yonne to the borders of Esconne at Chevannes, about thirty-seven miles in length, which is to cost eight millions of francs.

" This aqueduct, which traverses the Forest of Fontainebleau through its whole length, comprises two and one half to three miles of arches, some of them as much as fifty feet in height, and eleven miles of tunnels, nearly all constructed of the material excavated, the impalpable sand of marine formation known under the generic name of Fontainebleau sand. It includes, also, eight or ten bridges of large span (seventy-five to ninety feet), for the bridging of rivers, canals, and roads. This work was commenced about the middle of the year 1868, and is to be completed in three years. Already, in eight months, one-third of the work is finished. Several miles of arches are built. These arches are forty feet span, are fifteen and three-quarter inches in thickness at the crown, and in some instances they are fifty feet in height. They have been constructed without interruption through the heat of summer and the frosts of winter, and they have been entirely unaffected by either extreme of temperature. Built in ordinary masonry, similar arches ought not to have had over twenty feet span ; with a span of forty feet they would be really wonderful ; but they are all the more so, since they have been made of agglomerate, the base of which is the Fontainebleau sand, so fine that it never is used even for making mortar. It would not be possible to find a more complete demonstration of the value of our process, since even with Fontainebleau sand we accomplish the boldest works ; and so completely has this won the confidence of the engineers, that eight bridges, of from one hundred to one hundred and fifteen feet span, which were to have had iron stringers, are now to be constructed entirely of agglomerate. This fact, more than any thing I could say, bears testimony to the value of this material.

" It is also with agglomerate, having for its base impalpable sand, that we are building the underground portions of the aqueduct, which pass through enormous masses of fine sand, and demand constant precautions to avoid caving. We have been compelled to adopt an entire system of sheathing and of centres especially adapted to the work. Success has so well attended our efforts, that we have, up to this time, met with no accident, and in spite of the manifest inferiority of the sand used, we have succeeded in running a tunnel of a single piece without a joint, the hardness of which is all that could be desired, with strength enough to resist, easily, the great pressure arising from the tendency to cave in of the running sand through which the work passes.

" We have thus proved, a second time [the first having been in the tunnel of the grand sewer of Saint Denis, under the Railroad du Nord], that the use of agglomerate for the construction of tunnels and underground work possesses a great superiority over common masonry.

" In fact, while common masonry leaves spaces behind the sides and above the arch, the agglomerate, by its very nature, crowds back the surrounding soil, compresses it, and fills all spaces, so that the entire circumjacent mass becomes incorporated with it, thus manifestly securing great solidity, largely increased by the absence of all joints, by which all leaking is prevented, which is the frequent cause of the accidents which so often happen in tunnels. A tunnel constructed of agglomerate is a monolithic tube without joints, homogeneous throughout its entire mass, and sustaining pressure with the maximum power of resistance.

" I have, moreover, in the construction of the aqueduct of Vanne, solved one of the most interesting problems. I have succeeded in rendering filtration absolutely impossible—'mathematically' so, to employ the expression used by the Government inspectors in their report, and this, too, without having recourse to the usual linings or coatings. These linings, you know, often have a thickness of several inches, and are then quite expensive ; but their

chief defect, especially when applied to agglomerate, is a tendency to detach themselves from the masonry on account of the inequality of expansion, and to crack when the cement used is not of the first quality. The success has been complete and absolute; subjected to trial, the loss of water was nothing.

"This method, stopping all filtration, is of great advantage in the construction of basins, cisterns, and reservoirs made with agglomerate; works which, in general, it is so difficult to build without a tendency to leak, and upon which the action of the weather is so frequently injurious.

"As a proof of the confidence to-day given to agglomerate, I will instance the hollow blocks which we have constructed for the dock at Bordeaux, and also the sewers of Odessa, which have been constructed by this process.

"Above all, I will call your attention to the construction of the light-house at Port Saïd, which has just been intrusted to us.

"This light-house will be one hundred and eighty feet high; it will be entirely built of agglomerate, made from the desert sand, analogous to that of Fontainebleau; and it will rest upon a monolithic block of agglomerate of nearly four hundred cubic yards dimensions. It is almost an exact copy of the Baleines light-house, executed after the plans and under the orders of Mr. Léonce-Reynaud; Engineer-in-Chief. When it shall have been completed, I will have the honor to submit to you a special report upon this remarkable work.

"I have now called your attention to the principal works, more or less monolithic, which we have executed, and it remains for me to present to you certain applications and improvements, not less important, which we have accomplished in the adaptation of artificial stones to all kinds of buildings; but, before this, allow me to offer my tribute of thanks to those eminent men, Messrs. Belgrand and Alphaud, engineers, and Mr. Caillat, architect, who were the first to grasp the great future of the agglomerate, and did not fear to take the initiative in its use on a large scale. Permit me also to thank Mr. de Lesseps, the distinguished man who assumed the responsibility of awarding the construction of the light-house of Port Saïd to us.

"As I have before said, the result of our process increases twenty-fold, and even more, the adhering properties of lime and cement, so that by our method *we do make stone* which resists a crushing weight of considerably over seven thousand pounds to the square inch.

"It is evident that we have found this wonderful hardness of great use to us in the construction of flag-stones, flights of stairs, door-steps, landing-places, parapets, curves, balusters, etc.; and in fact, we not only daily deliver these articles to private individuals, but we have furnished large quantities to the city of Paris. I will particularly mention the stair-ways to the cellars of the Grand Opera House, which have given every satisfaction to Mr. Garnier, the architect of this beautiful structure.

"Besides being able to obtain, simultaneously with stability, color, grain, and finish of form, we have gone largely into the manufacture of ornamented and moulded stones; our reproductions of sculpture are true works of art. Ornamented stones for buildings, doors, windows, balconies, cornices, and balustrades, by universal consent, have been brought to perfection; and as we offer all these at prices notably less than those of ordinary stone, the demand for them increases daily."

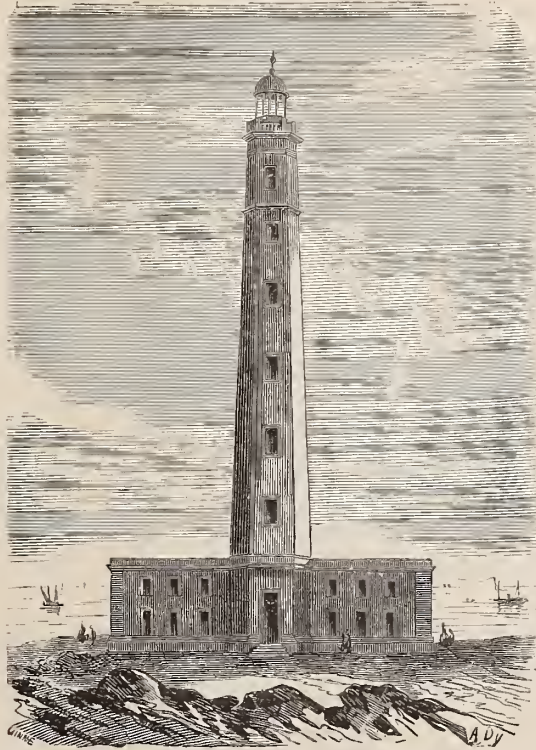
Extract from Reports of U. S. Commissioners, Paris Universal Exposition, 1867. on Beton-Coignet, by Leonard Beckwith, Civil Engineer:

Different varieties of béton-coignet tested at the Conservatoire des Arts et Métiers give the following results, indicated in the annexed table :

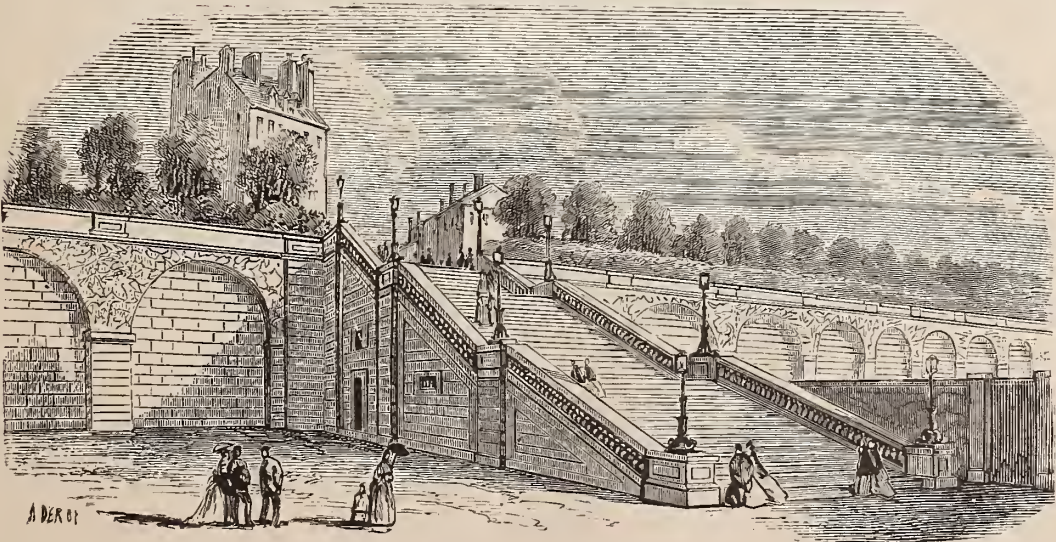
Experiments on the Crushing Strength of Coignet Agglomerate, made at the Conservatoire Impérial des Arts et Métiers, by Mr. P. Michelot, Chief Engineer in the Ponts et Chaussées, Paris, July, 1864. Dimensions calculated to nearest ¼ inch.									
Date of Fabrication of the Samples.	Age of the Samples.	Dimensions in Inches.			Weight in Pounds of a Cubic Yd.	Crushing Strength in Pounds.		Remarks.	
		Length.	Breadth.	Height.		Total.	Per Square Inch.		
February, 1862*.	Yrs. Mos. 2 6	{ 3 2 }	2½ 1 }	3½	3508 }	28,240,216 35,744,372	3269.56 4130.77 }	Fissured Composition of vaults of City Barracks.	
January, 1862*.....	2 7	{ 3 2 }	2 1½ }	2½	3665	44,641,073	4545.56	The small lateral prism was first crushed, but large prism resisted well.	
January, 1862.....	2 7	3	2	3½	3521	24,893,170	4171.78		
February, 1863*..	1 6	{ 3 2 }	2½ 1 }	3½	3747	34,638,544	4039.64	One corner of the sample was damaged previous to the experiment.	
February, 1862...	2 6	4	3½	4	3831	72,457,942	5649.58		
November, 1862..	1 9	3	2½	3½	3950 }	46,874,651 50,109,772	7175.89 7495.07 }	Fissured.	
November, 1862*.	1 9	{ 3 2 }	2½ 1 }	3	3821	48,018,896	5549.00		
November, 1862*.	1 9	{ 3 2 }	2½ 1 }	3½	3774	33,467,443	5364.38		
May, 1863*.....	1 3	{ 3 2 }	2½ 1 }	3½	3604	23,462,325	2682.48	Composition of the Church of Vésinet.	
May, 1863.....	1 3	{ 3 2 }	2½ 1 }	3½	3611	23,051,608	2634.14		
1862.....		2	2	3½	3518	16,821,228	4012.48		

* The samples marked with an asterisk have the form of a T. The double numbers in the columns of length and breadth indicate the size of the two rectangles composing the total surface.

Most of the bétons in the preceding table are stronger than is necessary for ordinary uses, and if used, the thickness of the structure, as compared with common masonry, may be diminished.



*Light-House, Port Said, entrance to Suez Canal.
Erected in 1869. 200 feet high.*



Stair-way to the Avenue de l'Empereur. Built in 1866.

The tensile and bearing strength of bétons is variable, as is that of every kind of stone. The following table shows the range of strength in the particular kinds, and the relative strength of the different kinds of building materials named:

	Mortar.	Concrete.	Brick.	Lime-stone.	Sand-stone.	Coignet Agglomerate.	Granite.
Crushing strength in } pounds per square inch. }	280 to 2100	} ... }	550 to 1700	4000 to 5500	2200 to 5500	2634 to 7495	5500 to 11000
Tensile strength in } pounds per square inch. }	50 to 290	77 to 360	115 to 300	120 to 864	180 to 900	288 to 426	

A cubic foot of béton-coignet weighs about one hundred and forty-five pounds.

APPLICATION OF BETON.—*Conclusion,*

WAREHOUSES, CHURCHES, GRANARIES, CELLARS, FOUNDATIONS.

Structures and buildings of solid masses of béton suffer less than ordinary materials from unequal settling of the ground, and underground rooms and cellars built of it are particularly free from damp.

The railway station at Suresnes, several houses at St. Denis, the church at Vésinet, etc., are examples of this kind, and, from the absence of joints, are the same as if made of one block of stone.

Cheap dwellings for workmen are now in course of construction in several localities in France.

A small house of béton-coignet was exhibited at the Champ de Mars, with specimens of arches, piers, slabs, statues, fountains, etc., finely moulded and well made by Mr. Coignet.

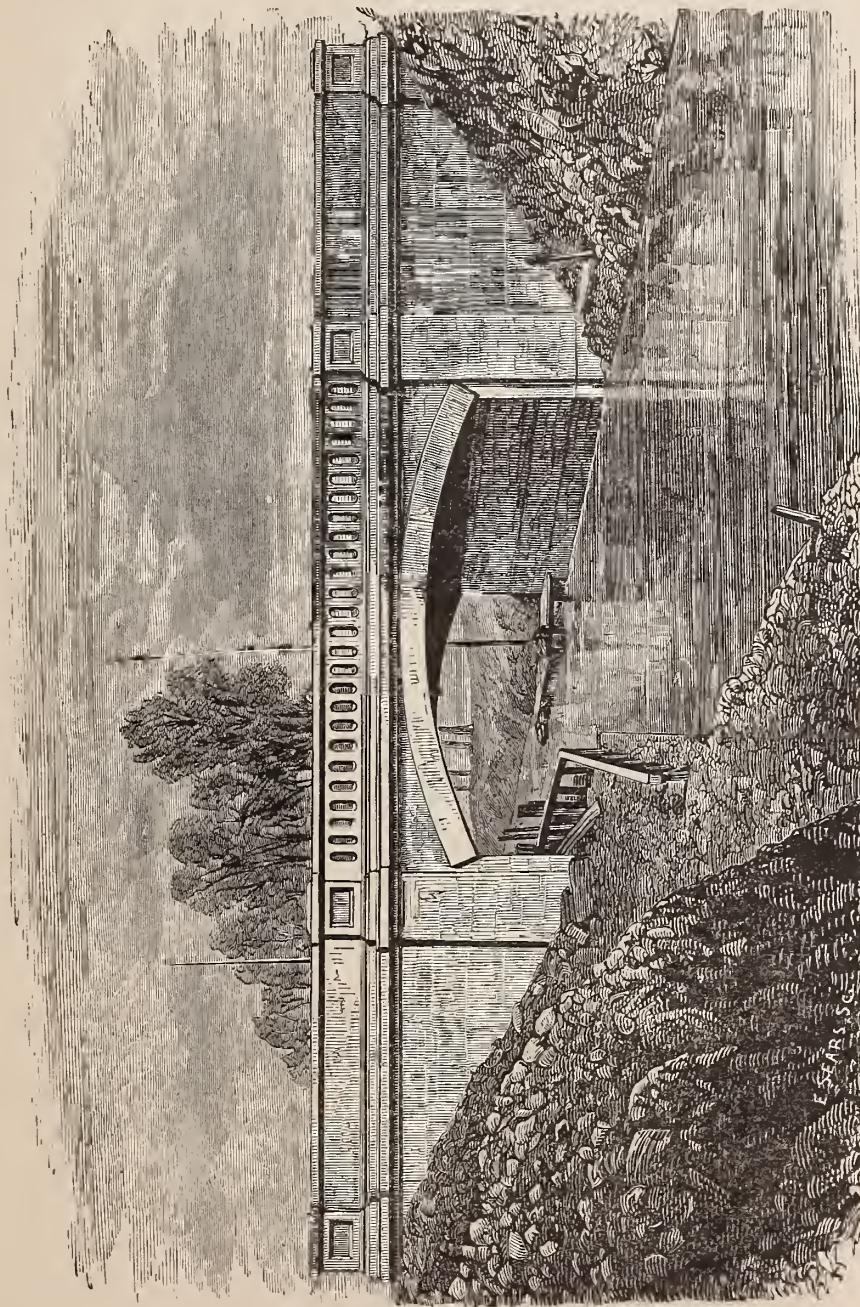
ARCHES AND VAULTS.

Various experiments have been made, with good results, to test the strength of the béton for arches, and it is now much used for that purpose; in the structures of the Northern Railway at Paris, in the new prison of the Madelonnettes, and in the new barracks of Notre Dame. In the latter, an arched vault was built of 18 feet span, $1\frac{1}{2}$ feet versed sine, $8\frac{1}{2}$ inches thick at the crown, with surface of 14 square yards, on which experimental weights of 47 tons were placed for a fortnight without damage. Béton was afterward used for all the similar arched vaults in the building, giving a surface of 3,588 square yards.

An experimental arch on the Quai de Billy has a span of $55\frac{1}{2}$ feet, versed sine 4 feet, thickness of crown 14 inches, with good results.

At Aubervilliers, the machinery of a considerable saw-mill is placed on an arch of 33 feet span, versed sine $6\frac{1}{2}$ feet.

The ventilation of the Exhibition building, at the Champ de Mars, is effected by underground works, consisting of a series of circular and railed galleries, arched with béton, span about 10 feet, for the circulation and supply from below of cool air through openings in the floor.



Bridge of Beton-Coiğnet.

The outer gallery is 33 feet in width, and 1,443 yards in length; the groined arches of béton are supported on two rows of béton pillars, 864 in number, carrying a roof, the upper surface of which forms a floor of 15,873 square yards of surface.

The quantity of béton consumed in these galleries was 353,166 cubic feet.

WALLS.

The embankment on which runs the Avenue de l'Empereur, at the Trocadero, for a quarter of a mile, is supported by a wall of béton about 40 feet high; the outer side is strengthened by pilasters; the inner side consists of a series of arches at right angles to the wall, built one upon the other, and extending into the embankment, forming a bearing for the mass of earth, and diminishing its lateral pressure against the wall. The walls and arches are a solid mass of béton.

The steeple of the church of Vésinet is constructed of béton, 130 feet high, and shows no sign of weakness.

FLOORS, TERRACES, ROOFS.

If the area does not exceed 13 or 16 feet in width, a slab of béton 10 or 12 inches thick will be strong enough to sustain itself; if the area be greater, double T-joists of iron should cross the space for ceilings, floors, etc., and the slabs of béton may be made thicker or thinner, depending on the distance of the joists one from another, the flanges of which form the holding of the slabs.

Joists being thus placed, and a temporary scaffolding or floor of boards erected underneath, the béton is dumped upon it and packed; the edges hold upon the flanges, the béton hardens, the scaffolding is removed, and the ceiling remains firm; if the upper side should serve for a floor also, the béton should be laid thicker and carried over the joists, so as to form a smooth surface above them.

FLAGGING SIDEWALKS.

Béton, being impervious to water, and without joints, no moisture is absorbed beneath, if the ground be properly drained, therefore no heaving or disturbing results from frosts in the ground. Flagging and floors of béton for courts, stables, cellars, coach-houses, schools, railway stations, warehouses, etc., etc., are much used.

FOUNDATIONS FOR MACHINERY.

Foundations for machinery, of béton, are usually cheaper, and as good as masonry of stone. For engines, a cubic yard of béton corresponds to a horse power, and a thirty-horse power should have thirty cubic yards of foundation.

Foundations of béton for water-wheels and turbines may be seen at St. Maur; for steam-engines, at the percussion-cap factory at Paris, the tobacco factory at Châteauroux, the glass works at St. Gobain, etc.; at Oyssel, a steam-engine of four hundred-horse power, which works admirably, rests on a block of béton 7 yards in thickness, and at the Exposition of 1867 a great portion of the machinery was placed on béton foundations laid in winter, and worked well.

SEWERS, AQUEDUCTS, WATER-PIPES.

Twenty-five miles of main sewers in Paris have been made of béton, and its use for this purpose is rapidly increasing.

Water-pipes of béton are made at half the expense of iron, and they cost little for repairs. The whole of the underground drainage of 40 acres roofed by the palace of the Exhibition, was through béton-coignet pipes of 12 to 16 inches tube, discharging into sewers of béton. The cubic contents of materials used in these pipes amounted to 264,825 cubic feet.

CISTERNS, RESERVOIRS, TANKS, CESSPOOLS.

These, when built of masonry and coated with cement, are impervious to water, but need constant repairs; of *béton-coignet* they are equally impervious, cost less, and are more secure.

A cistern 39 feet in depth, 5 feet in diameter, with sides 10 inches in thickness, after two days receives water, and remains sound an indefinite period.

The cesspools of *béton*, authorized by the Prefect of the Seine in 1862, are without cement, hold good, and are water-tight; structures of this kind are adopted for the great opera house now building, and for the great railroad stations, etc., etc.

Gasometer tanks of large dimensions, 130 feet diameter, 49 feet in depth, are built of common *béton-coignet* at Rueil and St. Denis. The difficulties of making structures of this size in masonry water-tight are said to be much less in *béton-coignet*.

MARINE STRUCTURES—EXPERIMENTS OF MR. COIGNET.

Mr. Coignet's first experiments were begun, by order of the Government, in November and December, 1858, and January, 1859, on the Socoa breakwater at St. Jean de Luz, in a very exposed situation. The blocks were of several kinds, and all are alike in good condition at this date (1867), and have resisted the action of sea-water with satisfactory results. They are compact and hard, and the only effect noticed has been the wearing of the edges of the blocks and the rounding off of the angles, produced by the friction of pebbles and the general mechanical action of the sea.



*Buildings of Beton-Coignet, Rue Miromenil, Paris.
Built in 1867.*



Church in Vesinet, France. Built of Beton-Coignet, 1863.